Radionic Non-uniform Black Strings

Takashi TAMAKI, Sugumi KANNO and Jiro SODA
Department of Physics, Kyoto University, 606-8501, Japan

Abstract

Non-uniform black strings in the two-brane system are investigated using the effective action approach. It is shown that the radion acts as a non-trivial hair of black strings. The stability of solutions is demonstrated using the catastrophe theory. The black strings are shown to be non-uniform.

1. Introduction and Summary

In the Randall-Sundrum 1 model [1], the black hole can be regarded as a section of the black string as long as the distance between two branes is less than the radius of the black hole on the brane. As the radion controls the length of the black string, it can trigger the transition from the black string to localized black hole through the Gregory-Laflamme instability. The purpose of this work is to reveal the role of the radion in the black string system with the hope to understand this phenomena. We take the specific model that the dilaton field coupled to the electromagnetic field on the $\oplus$-brane. In the case of stable black string, we can use the low energy approximation that the curvature on the brane is smaller than the curvature in the bulk. Foutunately, the effective action is known in this case as [2]

$$S_{\oplus} = \frac{1}{2\kappa^2}\int d^4x\sqrt{-h}\left[\Psi R(h) - \frac{3(\nabla\Psi)^2}{2(1-\Psi)}\right] - \int d^4x\sqrt{-h}\left(\frac{(\nabla\phi)^2}{2} + \frac{e^{-2a\phi}}{4}F^2\right),$$

where we defined $\Psi := 1 - \exp(-2d/\ell)$. Here, d is the proper distance between the branes. The point is that the bulk metric is completely determined by the 4-dimensional theory through the holographic relation [2]. Using this fact, we have investigated the bulk geometry of this system and found stable non-uniform black strings for which the radion plays an important role. In the following, we provide views both from the brane and from the bulk.

2. View from the Brane

From the relation between the mass $\bar{M}$ and the inverse temperature $1/\bar{T}_H$ in Fig. 1. (a), we find that the non-trivial radion ($\Psi \neq 0, 1$) interpolates Reissner-Nordström (RN) and GM-GHS solutions [3]. According to the catastrophe theory, the stability changes at $d(1/T_H)/dM = \infty$ [4, 5]. Since we cannot find the point $d(1/T_H)/dM = \infty$, our solutions are stable.

3. View from the bulk

We present the example that the circumference radius shrinks toward the $\ominus$-brane in Fig. 1. (b) where $\oplus$-brane and $\ominus$-brane are placed at $y = 0$ and $y = 1$, respectively. We can show that this tendancy is generic and hence the radionic black string is non-uniform [6].

References

[1] L. Randall and R. Sundrum, Phys. Rev. Lett. 83 (1999) 4690 [arXiv:hep-th/9906064]; *ibid.* 3370 [arXiv:hep-th/9905221].

[2] S. Kanno and J. Soda, Phys. Rev. D66 (2002) 083506 [arXiv:hep-th/0207029]; *ibid.* 043526 [arXiv:hep-th/0205188].

[3] G. W. Gibbons and K. Maeda, Nucl. Phys. B298 (1988) 741; D. Garfinkle, G. T. Horowitz and A. Strominger, Phys. Rev. D43 (1991) 3140.

[4] O. Kaburaki, I. Okamoto, and J. Katz, Phys. Rev. D47 (1993) 2234.

[5] K. Maeda et al., Phys. Rev. Lett. 72 (1994) 450 [arXiv:gr-qc/9310015].

[6] T. Tamaki, S. Kanno and J. Soda, arXiv:hep-th/0307278.

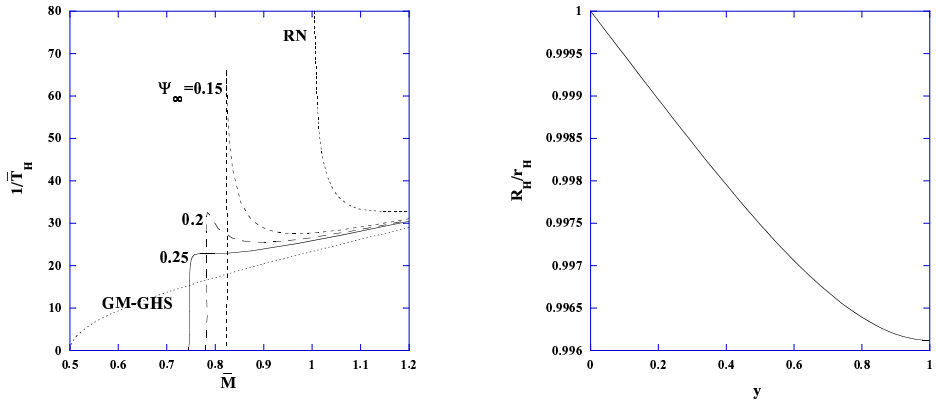

Fig. 1. (a) M-$1/\bar{T}_H$ and (b) the horizon in the bulk.